China Motor Systems Energy Conservation Program

Case Study

Performance Optimization of Pump System of a Pharmaceuticals Company

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Summary

In 2002, Shanghai New Asiatic Pharmaceuticals Co., Ltd., (SNAPC) with assistance from experts from UNDIO and Shanghai Energy Conservation Center, improved the pumping system for cooling water. The plant decided to evaluate its pumping system because it was having problems matching the flow rate of the pumps to system requirements, which led to excessive pipe resistance and extremely small temperature difference between supply water and return water. Based on the evaluation, the plant implemented a project that improved the pumping system's effectiveness by applying proper pumps and adding a Variable Frequency Drives (VFD) to the system. The total cost of the project was RMB 1,200,000. With annual energy savings of 1.09 million kWh or RMB 660,000, the project's simple payback was just 1.8 years.

Plant Overview

SNAPC, one of the pioneers of the pharmaceuticals industry in China, was established in 1926. The total production value was 3 billion RMB in 2001. There are more than 120 products in this company which can be divided into six categories, including bulk pharmaceuticals, pharmaceuticals, health products, packing materials for pharmaceuticals, and so on. SNAPC has been nominated as a 'Hi-tech Enterprise', 'Advanced Unit', and 'Civilized Unit' every year for the past five years. SNAPC consumes about 16.98 million kWh every year, which accounts for 60% of all energy consumption. The circulating water system consumes about 2.15 million kWh every year, which accounts for 13% of electricity consumption.
Website: http://www.xinyapharm.com

Shanghai New Asiatic Pharmaceuticals Co., Ltd.

Project Introduction

The cooling water system consists of 4 parallel pumps (160kw×3,75kw×1) and 5 500t/h cooling towers with 15kw fan for each tower. The cooling water system is illustrated in the following diagram.

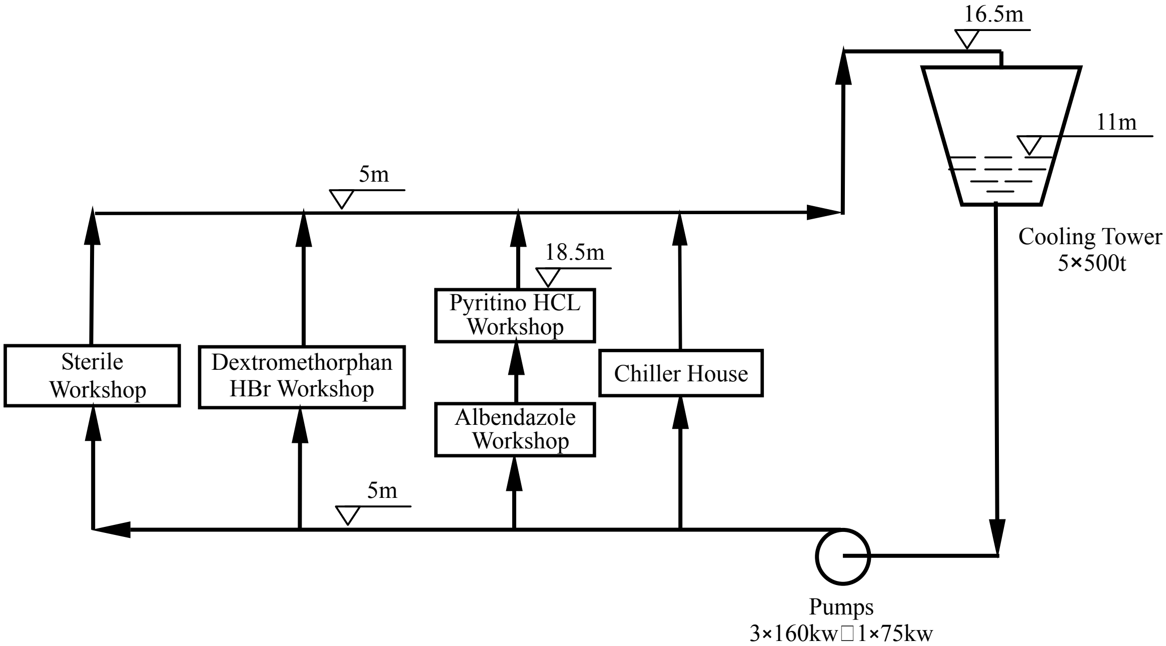


Figure 1 Pumping system diagram

The cooling towers are located on the top of the building of 11 meters high, and the water pumps are mounted in the first floor, whose elevation is zero. Two 160kw pumps usually operate at the same time and another one is used for a backup. These two pumps run 5000 hours annually and consume about 1,788,000 kWh of electricity. The 75kw pump operates 4000 hours every year and consumes about 243,000 kWh of electricity. This cooling water system is mainly responsible for cooling chillers, compressors, vacuum pump and production processes such as Sterile Workshop, Dextromethorphan HBr Workshop, Pyritino HCL Workshop. 80~90% of the circulating water is used for chillers. The design parameters of the pumps are listed in the following table.

Table 1 Original Pumps Design Parameters

Model	Quantity	Flow rate (m^3/h)	Head (m)	RPM (rpm)	Efficiency (%)	Power (kW)
350S-44A	3	864	41	1450	84	160
300S-32A	1	551	31	1450	80	75

There are four chillers in this system, the design parameters of which are listed as following table. Normally, three parallel chillers operate at the same time, and one is used for back up.

Table 2 Designed Parameters of the Chillers

Flow rate (m^3/h)	Pressure Drop (Mpa)	Inlet Temp. ($^{\circ}C$)	Outlet Temp. ($^{\circ}C$)
328.6	0.0786	32	37

Project Evaluation

1. Measurement Results

Measurement was taken to capture the seasonal variation in the operating scheme. The measurement results of the power, head and total flow rate of the pumps are listed as following table:

Table 3 Measurement Results Table

Operation Combination	2*160kw	1*160kw+1*75kw	1*160kw
Power (kw)	312	220	158
Head (Mpa)	0.4	0.35	0.31
Flow rate (m^3/hr)	2200	1750	1100

2. Results Analysis

According to the measurement results, the following problems are identified in this system.

1) The pumps are oversized

According to designed parameters, normal pipe resistance loss and static pressure head, 28 meters head is enough for system requirement, but original system was equipped with three pumps of 41m head. Moreover, the total flow rate of the pumping system is so large for the system requirements that most of valves are not fully open to maintain the normal operation of the system.

2) The flow rate can't be changed according to actual system requirement

According to measurement results, system load varies greatly in different seasons. The maximum flow rate is up to 1350 m^3/h, but the average value is only 700m^3/h. Therefore, the flow rate of pumps should be able to be regulated to adapt to the system requirements.

3) The quality of circulating water can't satisfy the requirement of heat exchangers.

Project Implementation

1. Replacing the original pumps

Two new pumps with proper head and flow rate were installed to replace original pumps. The nameplate parameters of new pumps are listed as table 4. Normally, only one pump can match the system requirements, and it can be switched to another one automatically when something wrong happens with this pump. One 160kw pump and one 75kw pump operated before optimizations, which overall consumed about 220 kW electricity per hour. After optimization, one pump consuming only 70 kW electricity per hour under control of VFD can satisfy the total system requirements. Moreover, the inlet and outlet of the pumps were re-designed to further improve the efficiency of the pumps. In place of a sudden direction change at the inlet of the pump, some long radius elbows were installed at the upstream of the pumps, which created a more even velocity profile and minimized the head losses on the inlet side of a pump.

Table 4 Present Pumps Nameplate Parameters

Model	Flow rate (m^3/h)	Head (m)	RPM (r/min)	Efficiency (%)	Power (kW)
350-380	1424	31	1450	85.5	160

The configurations of the original and present pumps are illustrated as following pictures:

Original Pump System

Present Pump System

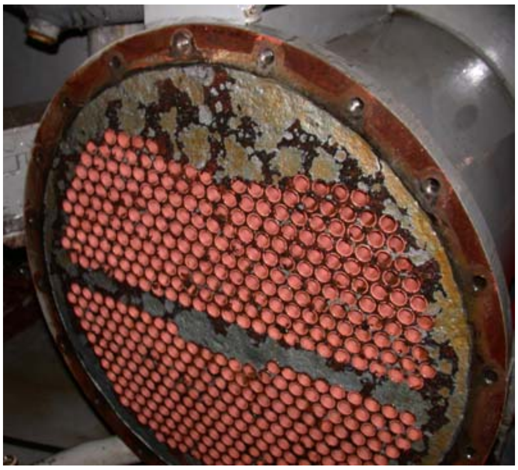
2. Applying automatic control technology

To address the large range of system load change, LG Variable Speed Drives and automatic control system were applied to pumping system, which offer a means to improve operating efficiency of the pumps. Automatic control system can drive VFD to regulate the speed of the pumps to match the system requirements according to the process requirements and the temperature of water returned to cooling tower.

3. Treating cooling water and pipe system

The water treatment technique of Shanghai Duo-Jia Water Treatment Science & Technology Company has been applied to clean the pipe system and heat exchangers of the chillers. As a result of the treatment, the resistance of the pipe system was lowered and the quality of cooling water was improved. The original resistance loss of the condenser of the chiller changed from 0.15Mpa to 0.20Mpa, and the pressure drop has been reduced to only 0.01Mpa after cleaning. In addition, the water treatment also

Condenser of chiller before cleansing



Condenser of chiller after cleansing

improved the heat transfer efficiency of the heat exchangers; the temperature difference between the inlet and outlet of the condenser increased about 1.5°C under the same flow rate.

Lessons Learned

Properly configuring a pumping system so that its capacity is suited to a plant's actual requirements is extremely important. Pumps can reduce the maintenance costs and consume the least amount of energy when they operate at the BEP on their performance curves. Different systems should be evaluated to effectively match the available pumping capacity to actual requirements. For Shanghai New Asiatic Pharmaceuticals Co., Ltd., replacing the original pumps and installing VFD are the appropriate and most cost effective solution for the pumping system's problems. The implementation of this project led to important energy savings and allowed the plant's pumping system to operate more effectively.

Project Financing

According to EMC mechanism, Shanghai Energy Conservation Center (SHECC) arranged the estimates for the pumping system and invested 1.2 million RMB in this project. SHECC and SNAPC would share the energy savings by 80% and 20% within 3 years according the contract signed by both sides.

Investment and payback calculation

Project Implementation Costs	RMB1,200,000
Annual Energy Costs Before Optimization	RMB 1,300,000
Annual Energy Costs After Optimization	RMB 640,000
Annual Energy Costs Savings	RMB 660,000
Simple Payback (years)	1.8

Energy Savings Calculation

Annual System Energy Usage Before Optimization	2.14 million kWh
Annual Energy Savings from Optimization	1.09 million kWh
Annual Energy Usage After Optimization	1.05 million kWh
Percent Energy Savings	49%